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On Military Surveying and Reconnaissance

Captain Baillie E.I.C.S.

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Medals.

A Silver Medal to celebrate the Siege of Gibraltar; presented by Col. Paschal.

Miscellaneous.

A Portrait of Lord Nelson and of the Duke of Wellington, with autographs.

A Medallion of Sir John Franklin; presented by John Barrow, Esq.

Pieces of Russian ration bread—Russian Soldier's Spoon, with blood in the ladle—Cap Pouches—Piece of fuse, which had been lighted to blow up the Magazine in the Redan—Russian Bayonet. Presented by Major Julius Raines, 95th Regt.

ON MILITARY SURVEYING AND RECONNAISSANCE.

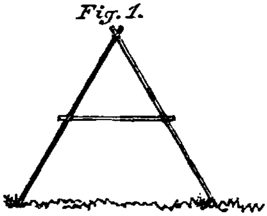
By Captain Baillie, E.I.C.S.

(*Abstract of Paper.*)

Capt. Baillie commenced by observing, that he would take for the text of his remarks the recent Order of H.R.H. the Commander-in-Chief, on the qualifications for staff officers, especially those of the Assistant-Adjutant-General's and Quartermaster-General's departments, which Order he read to the meeting. He would confine himself to the description of the purely practical methods of military surveying, such as it was within the power of every officer to make himself acquainted with, and which he should be able to apply at any time and under any circumstances, when called upon to do so. Military Surveying might be divided into two branches: 1st. Surveying with Instruments; and, 2nd. Without Instruments. The former was the easier and more correct method; the other being the result only of considerable practice and experience, and limited in a great measure to favourable circumstances of ground and locality generally. Surveying instruments might be classed as, those for linear, and angular measurement. Instruments for linear measurement were required to determine the length of a base line—which was the foundation of every survey,—and upon the correctness of which, the value of the whole directly depended. In military surveys, sufficient importance was not usually given to this the preliminary operation. In books on the subject it was rather slurred over; or they contented themselves with noticing one or two means of performing it—usually by the number of paces of a man or horse. Both these methods were very uncertain—the latter especially so.

Every staff-officer had usually two or three chargers, all probably differing in the length of pace, and each, again, varying its pace under peculiar circumstances. Then it was difficult to count any high number of paces while at full speed, and while, of course, the attention must necessarily, also, be diverted to the direction of the line, and the nature of the ground. Perhaps time furnishes a better mode of estimating distance,—the rate of speed of a cavalry charger being about 400 yards per minute. The other mode of measuring offered a better criterion,—the foot pace. But even this was uncertain. No two men, hardly, however well drilled, took the same number of paces in 100 measured yards, marching independently; and no single man made the same number three times running,—and, when it came to broken and irregular ground, it was of course still less to be relied on. It was therefore of great importance to obtain some simple means of measuring a base "instrumentally;" and the one he (the lecturer) had found the most convenient, was the ordinary pace-stick, with the use of which every drill-serjeant or corporal was well acquainted, by means of which they could measure any distance as rapidly as they could walk, and with the certainty of unvarying length of pace. It was equivalent to the process of "stepping" measurements on paper with the compasses, which till lately had been the only means of dividing straight lines for scales and circles, even of large astronomical instruments. A simple pace-stick could always be constructed with three rods fastened together in an equilateral triangle with two sides continued, as in the fig. (1); or a jointed one could be made by any regimental

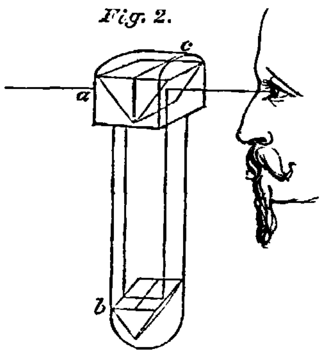
Fig. 1.



carpenter or armourer, and carried as a common walking-stick. There were other instruments especially adapted for measuring distances—such as the perambulator; and various optical instruments

·as the "stadium," and the "rochon," or micrometer telescope. he perambulator was well adapted for route surveys, but was too ımbrous for an officer to carry about with him. In India, a very rge one, twenty feet in circumference, usually accompanied the ·ad-quarters of each army. The perambulator might be usefully ›plied to gun-carriages. They had been frequently tried in ordi- ıry carriages, but failed there on account of the springs, as there as a difficulty in connecting the parts on the wheel, from which the .otion was derived, with those on the body of the carriage, where ıe dial or register was placed. Gun-carriages had no springs, and ıe objection, therefore, would not apply to them. One perambu- .tor in each troop or battery would be useful; and on fair ground ı would easily give a short base from which to ascertain distances ›r range. The micrometer telescopes were good, but, generally, ›o expensive for common use. One had recently been produced, ʼhich might be referred to, as it differed from all the others in the onstruction of the telescope, which was on a new principle. It was alled the "Napoleon III." field-glass, invented by a French officer, I. Porro, who sought to combine in it the long focal length of the ld draw telescopes with the more compact form of the modern louble field-glass. He had done this very cleverly, by folding up he length as it were into four, on the principle of the "optical ›aradox," only that prisms were substituted for reflectors; the dia- ;ram represents the instrument. And it was evident that a ray of

Fig. 2.

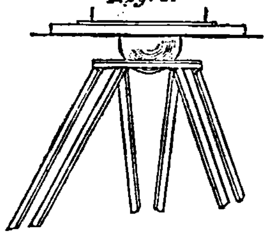


light, entering the telescope through the object-glass or prism at A, would be refracted thence up again to C: and so to the eye. The micrometer was engraved on one of the prisms. The instrument combined great steadiness with long focal distance and large field of view. The cost in Paris was about six pounds.

We will suppose that by either of these methods we have succeeded in measuring a base line; the next point is to select the stations for the various triangles which form the net-work of the survey. The equilateral is the best form of triangle for this purpose, and the angles should never exceed 90° or be less than 30°, as extremely obtuse or acute angles are liable to considerable error. The choice of the marks of the different stations must of course depend upon the nature of the country; they may be trees, prominent rocks, and stones; or buildings, spires, towers, chimneys, &c., afford good marks; but angles of buildings and walls should be avoided, as they are often concealed or undistinguishable from the contiguous stations. In some cases it may be necessary to use artificial marks entirely; the best of these are those which, on the principle of the "Heliotrope," or as it is more correctly called "Heliostat," reflect the sun's rays to the observer, and thus afford a brilliant object visible at immense distances. The heliostat, as used in trigonometrical surveys, is a circular bit of looking-glass about six or eight inches in diameter, whose surface is a true plane; it is fitted into a brass frame, and supported on a horizontal and a vertical axis, so that it can be turned in any direction, either of azimuth or altitude, for military purposes. However, this would be a great deal too complicated and cumbrous; all that we require is a common "shaving glass," or, if that is not available, the lid of a tin box, or a tin plate or canteen, polished up with sand for the occasion. An orderly might be sent to the distant station with this, and directed to stick up his sword or a ramrod between himself and the position of the officer who is observing the mark, and by keeping the sun's rays playing upon the end of the ramrod or the hilt of the sword he will be enabled to direct them very accurately to the point of observation. The observer may have another mirror at hand, and, by flashing it a certain number of times towards the signal-man, he could convey any simple directions that might be necessary. Persons who are not acquainted with the use of mirrors in this way will be surprised at the immense distances at which the reflected light is visible. In the Ordnance Surveys a heliostat has frequently been observed at distances exceeding 100 miles; and at the Cape one of only three and a half inches in diameter was almost too brilliant for the telescope at 80 miles' distance. Mr. Galton, in his very valuable and interesting little work on the "Art of Travel," mentions that this plan of communicating signals is used on the plains of Australia and the prairies of America, and suggests its great value to shipwrecked sailors in open boats or rafts on the sea, where their signals are often overlooked. The same principle was also adopted by the Russians at Sebastopol as a telegraph.

We will next proceed to consider the means of measuring the angles and bearings of our station-marks. The earliest and simplest instrument for this purpose was the "plane-table," and, as it is still in use, it may be as well to describe it. It consists of a square wooden frame, or board, upon which a piece of drawing-paper is stretched, and which is supported on a tripod stand. In order to observe an angle or bearing, a flat rule furnished with two brass sights is provided, which sights are adjusted to coincide with the object to be observed, and a line drawn along the edge of the rule gives the required bearing. Formerly plane-tables were very complicated instruments, and in some of the old books on surveying they are represented with every imaginable contrivance of sights, telescopes, compass, protractor, levelling screws and levels, which were supposed to render them perfect, but in reality were only additional sources of error; but it was soon found that the mere expansion and contraction of the paper from hygrometric causes was sufficient of itself to produce an error of one-half per cent., and consequently no great dependence could be placed upon it, except for small spaces. For military purposes, however, where great accuracy is not required, it is still very useful; and one of the most convenient methods of making and using it is given in the Fig 3. For the table itself a

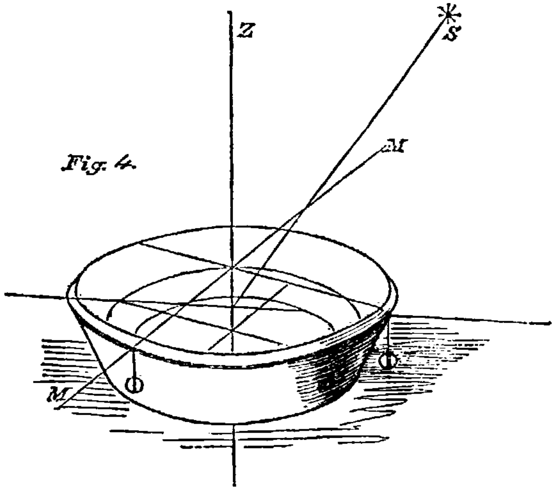
Fig. 3.



common block "sketch-book" is substituted, to which, underneath, is fastened a portion of a ball of common wood; this rests upon a tripod-stand, in the brass top of which there is a circular orifice (about two inches in diameter) to receive it, and forms with it a ball-and-socket joint, which admits of the surface of the sketch-book being placed truly horizontal. A flat wooden ruler with two needles fixed upright at the extremities, forms the sight ruler, with which bearings are observed and at once protracted. This is all that is requisite, and answers every purpose of the most complicated and expensive affair that can be produced by the mathematical instrument makers. The stand is the same as those now in such common use with photographic cameras, and has only lately come into use in England, but has long superseded the old folding tripod in India for all surveying purposes, and is superior to it from its greater stability. It can be made up anywhere by the commonest carpenter, and is equally useful for the compass, sextant, or telescope.

The next instrument for observing horizontal angles or bearings is the prismatic compass. It is so well known that any description of it is unnecessary. It was invented by Captain Kater for magnetic observation; but, from its portability, and the facility with which bearings could be taken by the "prismatic" arrangement, its advantages over the old circumferentor, or compass with sights, were speedily acknowledged, and it has quite driven that instrument out of the field. The compass card is usually divided to 180° on each semicircle; this, however, is objectionable, and liable to produce error in observation, and the card should in all cases be divided to 360° all round. A ring of silver is sometimes substituted for the card, but this only increases the expense considerably without any adequate advantage. The compass should always be provided with a stand like that of the plane-table described above. This is essential; for, although under very favourable circumstances a bearing may be taken to within 4° or 5° when the compass is supported in the hand, such bearings can never be relied on; the least wind disturbs the observation, and, in general, the angle between two objects can be much better estimated with the eye alone. If the compass must be used without a stand, the safest plan is to place it on the ground, and, standing over it, to align the sights upon the distant object, and then, kneeling down, to read off the angle without disturbing the compass; this always gives a much closer reading than the other method of holding the compass in the land, when the very effort of steadying the body and the instrument produces a vibration that entirely precludes accurate observation. Another great source of error arises from the hair-sight of the compass not being truly vertical, which is another argument in favour of the necessity of the stand. In most works on military surveying it is said that the card levels itself, and, consequently, no other levelling is necessary—but this is erroneous; it is not the card which is directed to the object, but the hair: and as it is frequently necessary to observe an object at a considerable height above the plane of the horizon, a very slight obliquity of the hair in this case will produce an error in azimuth of nearly 8° or 10°. Another irregularity of common occurrence, but which is very frequently overlooked, is that produced by what may be called local attractions caused not only by the presence of iron and other elements of disturbance in the earth itself, but, even in flat countries, by the vicinity of large masses of matter, such as houses, trees, &c., which exercise a direct and important influence on the magnetic needle; and smaller bodies of iron especially, which, from their vicinity, have almost an equal effect. It has been found that an observation of a star (Polaris for instance) will differ as much as 1½° from the reading with the same instrument, and of the same object, taken on opposite sides of a house; and an even greater error would be produced by the proximity of a steel scabbard or sword, a bayonet, or even a bunch of keys, or a knife in the waistcoat pocket, which, perhaps, few officers would think it necessary to leave behind them on a surveying expedition. It is necessary in using the prismatic compass over large tracts of country to be able occasionally to observe the magnetic variation, or, as it is now more commonly called, the declination; this may be done either by direct observation of the Pole-star at its elongations, or by finding a meridian line and comparing it with the magnetic meridian as indicated by the compass needle. Both these methods are described in most works on surveying; but there is another, which is very little known, and which, as it is applicable to many useful purposes in surveying, might be described here. It might be called a simple transit instrument, for it, when properly adjusted, would give the time by the transit of a star, or of the sun, with nearly as much accuracy as the largest and most expensive instrument for the same purpose. It consists merely of a vessel of water, mercury, or other fluid, over which two hairs or threads are stretched at right angles to one another as shown in the figure (4). It is evident that a star or

Fig. 4.



other object reflected from the surface of the mercury so as to be bisected by one wire, and its reflected image must be in a plane vertical to the surface of the mercury, and also of the earth at that point; if, then, the direction of the hair could be made to coincide with the true meridian at that place, the star, when bisected, must be upon the meridian, and the time then noted would be its time of transit. To make the hair or wire coincide with the meridian, it is only necessary to obtain sidereal time at the place, which could be immediately obtained approximately by noting the time of transit of a star at or near the zenith of the place (as shown by the reflected intersection of the wires in the mercury), when it must also be near or on the meridian. The right ascension of the star, as given in the Nautical or other almanack, would be the sidereal time of its transit, from which the time of transit of any following star could be deduced; and by moving the wire round, so as to bisect the star at that moment, it would be brought accurately into the meridian, or, if not quite accurate by one operation, it would be perfected by repeating it. Then by arranging the compass over the vessel of mercury, with its small mirror inverted, we can easily compare the magnetic with the true meridian, and at once obtain the magnetic declination at the place. It may be noticed here that the simple transit instrument here described forms the best sun-dial or meridian instrument that can be constructed; once brought truly into the meridian, it indicates the moment of the sun's meridian passage to a second. In conjunction with the box-sextant it also gives the sun's zenith distance, from which the latitude can be obtained; it is besides applicable to levelling or contouring with the sextant, as will be hereafter described, so that it forms what might be almost styled an universal instrument most invaluable to the military man.

The box-sextant is the next instrument ordinarily employed for military surveying that may be noticed here. It differs from the ordinary sextant only in being smaller and more portable, from its being encased in a box, from whence it derives its name. In general they are divided only to half-degrees, and furnished with a vernier, by which a reading to one minute may be obtained; and, with a little practice, even half a minute may be estimated. They are frequently provided with a telescope, but this is necessarily so small, as only to complicate the instrument, without being of any advantage. It is curious that this instrument is almost unknown out of England, and the writer recently met a French officer in the Crimea, who was exhibiting one, found in the Redan, evidently the property of an English officer, with the use or even purpose of which he was entirely unacquainted, as well as many officers of his own service to whom he had shown it. The method of using the sextant is given in all works on surveying, as well as its adjustments. These should be meddled with as little as possible; nothing tends to destroy any surveying instrument so much as the constant attempt to preserve it in perfect adjustment. This is really impossible; and all that can be done is to observe the index error of the instrument before or after each series of observations. It is necessary also to be cautious into whose hands surveying instruments are entrusted. He (the lecturer) had on one occasion lent his box-sextant to a gentleman whom he imagined was acquainted with the method of using it, and who returned it to him shortly afterwards, with the observation that "he had wound it up at both holes, but could not make anything of it." There is an objection to the use of the sextant in surveying—that it does not give horizontal angles, and that a complete series of angles round a station might considerably exceed or fall short of 360°. A little practice, however, would generally enable an observer to select a point above or below the distant station-mark in the plane of the true horizon; and by observing large angles, with long sides, the errors could never exceed those of the prismatic compass in the same circumstances. The effect of an error of one minute in the observation of a station-mark ten miles off would only amount to fifteen or sixteen feet, and for shorter distances it is much less; so that in a military survey, where great accuracy was not required or expected, this objection might be passed over. Each observed angle should be carefully noted down at once in the field-book. But, as even that gave room for mistakes, they should be distinguished by letters—A, B, C, &c.—and roughly plotted on the sketch-book at the same time; and in this should be inserted remarks and sketches of the nature and appearance of the station-points and marks, which would greatly assist the memory in completing the finished plan for submission to the authority for whom it was intended. In general, the unassisted memory should be relied on as little as was absolutely practicable. In the hurry of a rapid reconnaissance, points of the utmost importance would be overlooked or forgotten if left to the memory; while the most trifling pencil-scratch or note actually made on the ground, would help afterwards to recall the scene, and connect the various features of the sketch.

In all field-sketching of this nature, the delineation of irregularities of surface, such as hills, rocks, and broken ground, is the point to which most attention should be paid. If these are carefully laid down, the other features, such as roads, rivers, villages, &c., easily fall into their proper places; and it is precisely the point in which the memory can afford least assistance. The best method of observing differences of level is by running a few contour-lines round the hills at different altitudes; and the sextant is an excellent instrument for this purpose, as by a simple contrivance it makes a perfect levelling instrument, which is shown in the accompanying diagram (fig. 5). *a* is the sextant, supported

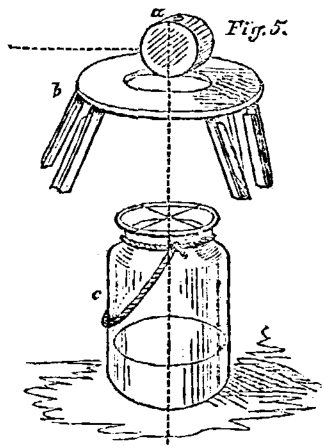
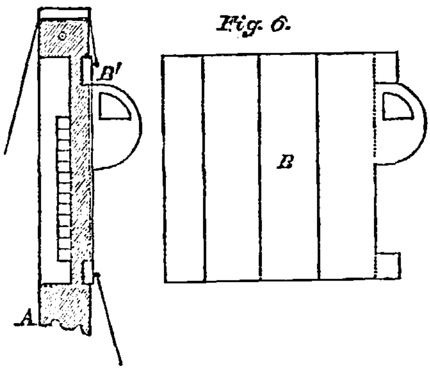


Fig. 5.

at the height of the eye by the stand (*b*) merely to steady it; *c* is a common glass-bottle with a large mouth (a pickle-bottle answers the purpose excellently), containing sufficient mercury to cover the bottom of the bottle completely. Round the neck of the bottle a piece of thick cord is fastened with a loop to carry it by, and over the mouth two cross threads, hairs, or wires, are fixed, with sealing-wax or resin, at right-angles to one another. There is also a tin or paper cap to the bottle to protect the mercury from dust, &c. when not in use. The bottle is placed directly beneath the sextant, so that, on looking down through the top of the stand, the wires and their reflected image in the mercury may be brought into exact coincidence when the eye must evidently be directly vertical to them. If, then, the sextant be set to 90°, and interposed between the eye and the wires, so that they can be seen through it, any object seen in coincidence with the wires in the half-silvered mirrors of the sextant must make with them an angle of 90°, and consequently be in the true plane of the horizon at that place. Suppose such an object were the sight-vane of a levelling-staff, then the indication on the staff would be the difference of level between the station of the staff and the point of observation, + the height of the eye at *a*. In this way a contour-line could be run in about one-tenth of the time that would be required were the spirit-level used, as the mercury quickly comes to rest, and from the shape of the bottle the wind can have little or no effect upon it. It has also another advantage over the spirit-level in levelling down a steep slope, where a single observation gives the angle of elevation or depression, which could otherwise be obtained only by repeatedly setting up and removing the spirit-level. This "sextant-level," in other arrangements and modifications, is also available as a dip-sector, zenith-sector, and vertical-collimator,—but it is unnecessary here to enter into a description of them.

As a levelling-staff, or even two or three, is required in contouring, a simple one is given here, which has been found convenient, and which may be made up almost in any position where a deal rod and a piece of tin can be obtained. *A* (fig. 6) is the levelling-

Fig. 6.



staff—a common deal rod, about 10 feet long by $1\frac{1}{2}$ inch square, in section—it is divided to feet and tenths of feet, in preference to inches. *B* is a sheet of tin cut out in the form given, so as to fold round the staff, and form a sliding vane. On the part which overlaps, a vernier-scale is made, which enables the staff-man to read the height of the vane to 100ths of a foot. The vane is moved up or down on the staff, according to signal from the observer, by a thin cord running freely through a hole or over a pulley in the top of the staff. The vane being of bright tin can be seen at great distances.

It has been already observed, in the commencement of this paper, that sketching without instruments can only be acquired after considerable practice and experience. Indeed it is impossible to lay down any rules for it, as the method of making the survey must vary for every locality, and depends entirely on the nature of the distinguishing features of the ground which is the subject of the survey. The usual method was to select the prominent elevations of the ground for stations, and from these to sketch out as much of the ground as could be seen from them, noting especially the points of intersection of the lines connecting the principal stations with each other; in this way a network of triangles was formed, as in a trigonometrical survey, which confined the errors of the position of the features of the ground within certain limits; and it was on the frequency of these intersections that the accuracy of the survey depended.

In conclusion, it might not be amiss to add a few remarks on the delineation of ground in military drawing. This must be always in a great measure conventional, because no merely pictorial representation of the surface of a tract of country, as seen in plan, could afford any indication of its absolute elevations or depressions. It was necessary to introduce shadows, and to exaggerate these even considerably, to produce the appearance of relief, and, where the brush was used, to depict ground. This method of delineation was undoubtedly the most perfect, but it was necessary at times to use the pen instead of the brush, and hence arose the two methods of representing hills now in common use, called respectively the horizontal and vertical methods. These are best described by reference to the effect of water upon a tract of hilly ground. In the vertical method the strokes or hatches of the pen represented the direction which would be taken by water or rain falling upon the top of the hill and running down to its base; the lines or hatches were, consequently, always perpendicular to the "water-shed." In the horizontal method the strokes of the pen represented the lines or "contours," that would be produced by the subsidence, at regular intervals, of a large body of water which has completely covered the hill; the strokes are, therefore, generally parallel to the "water-shed." A good practical illustration of this mode of representing hills was afforded by the "parallel roads or terraces" of Glenroy, in the Highlands of Scotland, supposed by geologists to be ancient "sea-beaches." Till of late years the vertical method of shading hills was the only one acknowledged and practised in the British or Continental armies; but recently the improvements on the horizontal system, or rather the adaptation of it to "contouring," have rendered it so superior to the other that it will probably entirely supersede it. In the French army this was already the case, and in their topographical department the "contour" system was solely used for the delineation of hills. The relative advantages of the various methods would be better understood by an examination of plans executed in the different styles (which were exhibited during the lecture). Mr. Wyld's Atlas of Battles in the Peninsula showed some good specimens of brush-work (lithographed); but in these the shadows were generally so exaggerated that it was difficult to make out the movements of the troops which they were intended to illustrate. The Plan of Sebastopol, published by our own topographical department, was a specimen of the vertical method; and a plan of the same place, from a French work (the *Journal des Sciences Militaires*), illustrated very beautifully the superiority of the "contour" method, as with a knowledge of the vertical distance of the contours the relative height of any object, and its absolute height above the sea-level, was immediately obtainable. In contrast to all these, some beautiful photographs from a model of a part of the Alps (Monte Rosa) were exhibited; these might be said to illustrate the "pictorial" method, entirely divested of all conventionality, and might be taken as a standard of excellence in brush-work, as the flat shades of the photograph could only be imitated by the brush. A comparison of the conventional methods was decidedly in favour of the contour system as used by the French, without shading of any description; and too much attention could not be directed to the study of this method. It afforded also a very simple method of modelling from Nature, as, if these contours were each traced separately on pieces of cardboard, cork, or similar material, and then cut out and built up in their proper positions, they at once furnished a correct model of the general surface of the ground delineated in the plan. The recent introduction of sand-modelling into our Military Colleges must also prove of immense advantage to young officers in acquiring a rapid knowledge of ground—in its relation to military purposes. A beautiful specimen of modelling in this style was to be seen at E.I.C.'s Military College at Addiscombe in the representation of "Ehrenbreitstein and Coblentz;" and it was to be hoped that this system of practical education would be speedily adopted in all our military schools, as, next to actual field-sketching, it was only by the study of models that a young officer could hope to attain real proficiency in Military Drawing.

The Lecture here concluded, but in the discussion which followed some interesting remarks were made by Mr. Galton and General Bagnold on the subject.

Monday, 1st June, 1857.

Colonel the Hon. JAMES LINDSAY in the Chair.

ANNOUNCEMENT.

The CHAIRMAN said,—Before we proceed to the business of this evening, I have a communication to make to the Members of the Institution respecting the Model of Sevastopol; and, in order that the course which the Council have taken for the purpose of obtaining the most accurate representation of the theatre of the late war may be placed before you as concisely as possible, a Memorandum has been drawn up, which the Secretary will now proceed to read.

MEMORANDUM *relative to the* MODELS *of the* SIEGE *of* SEVASTOPOL *and of the surrounding Country.*

In the month of November, 1855, His Royal Highness Prince Albert signified his intention of presenting to the United Service Institution a Model of Sevastopol and of the South of the Crimea. In doing so His Royal Highness made a condition that the Council would take steps to mark in colours, or otherwise, as might appear most advisable, the exact position of the Allied Attack and Russian Defences at the time of he capture of the place, and he hoped that the opportunity would not be lost of acquiring and preserving in a public Institution a correct Model of the Siege.